

# DEMONSTRATION & EVALUATION OF MOVING-MAPS TO IMPROVE LANE NAVIGATION OF AMPHIBIOUS VEHICLES



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NRL Code 7440.1

Stennis Space Center, MS

September 9 -10 2003



| Report Documentation Page  |                                    |                                     |   | Form Approved<br>OMB No. 0704-0188                  |                                 |
|--|------------------------------------|-------------------------------------|---|---|---------------------------------|
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| 1. REPORT DATE<br><b>SEP 2003</b>  |                                    | 2. REPORT TYPE                      |   | 3. DATES COVERED<br><b>00-00-2003 to 00-00-2003</b> |                                 |
| 4. TITLE AND SUBTITLE<br><b>Demonstration &amp; Evaluation of Moving-Maps to Improve Lane Navigation of Amphibious Vehicles</b>  |                                    |                                     |   | 5a. CONTRACT NUMBER                                 |                                 |
|  |                                    |                                     |   | 5b. GRANT NUMBER                                    |                                 |
|  |                                    |                                     |   | 5c. PROGRAM ELEMENT NUMBER                          |                                 |
| 6. AUTHOR(S)   |                                    |                                     |   | 5d. PROJECT NUMBER                                  |                                 |
|  |                                    |                                     |   | 5e. TASK NUMBER                                     |                                 |
|  |                                    |                                     |   | 5f. WORK UNIT NUMBER                                |                                 |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br><b>Naval Research Laboratory, Code 7440.1, 1005 Balch Blvd, Stennis Space Center, MS, 39529</b>  |                                    |                                     |   | 8. PERFORMING ORGANIZATION REPORT NUMBER            |                                 |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)  |                                    |                                     |   | 10. SPONSOR/MONITOR'S ACRONYM(S)                    |                                 |
|  |                                    |                                     |   | 11. SPONSOR/MONITOR'S REPORT NUMBER(S)              |                                 |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT<br><b>Approved for public release; distribution unlimited</b>  |                                    |                                     |   |   |                                 |
| 13. SUPPLEMENTARY NOTES<br><b>Presented at the 2003 East Coast Amphibious and Mine Counter-Measures (MCM) Workshop, Panama City, FL. Sep.9-10</b>  |                                    |                                     |   |   |                                 |
| 14. ABSTRACT   |                                    |                                     |   |   |                                 |
| 15. SUBJECT TERMS  |                                    |                                     |   |   |                                 |
| 16. SECURITY CLASSIFICATION OF:  |                                    |                                     | 17. LIMITATION OF ABSTRACT<br><b>Same as Report (SAR)</b> | 18. NUMBER OF PAGES<br><b>19</b>                    | 19a. NAME OF RESPONSIBLE PERSON |
| a. REPORT<br><b>unclassified</b>   | b. ABSTRACT<br><b>unclassified</b> | c. THIS PAGE<br><b>unclassified</b> |   |   |                                 |

# OUTLINE

- **NRL MM Objectives**
- **Background**
  - *AAV, LCU navigation procedures*
  - *NRL MM system*
  - *Previous NRL MM tests*
- **FY03 MM Test Results**
- **Recommendations**

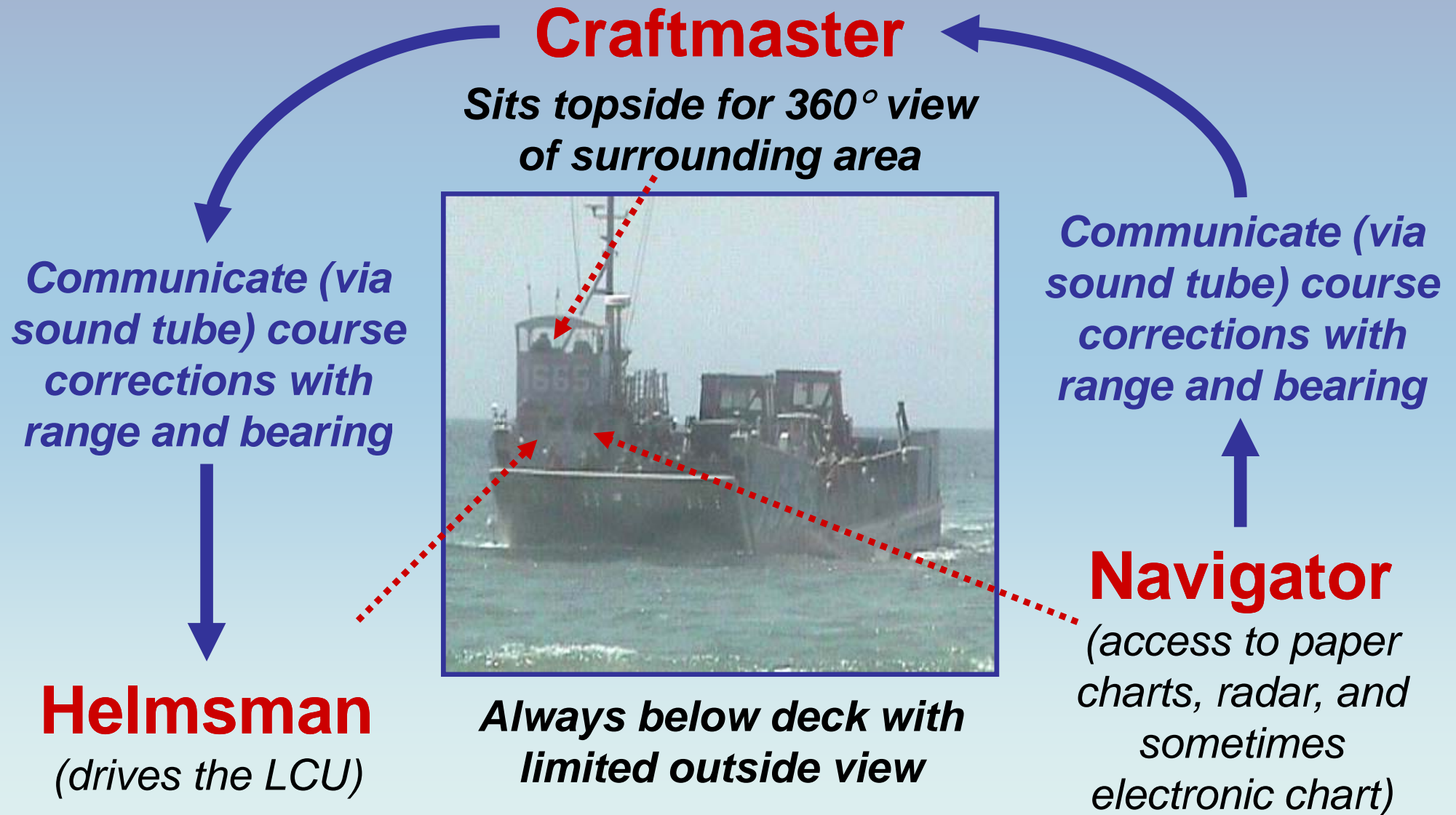
# NRL / MM (FY03)

- Demonstrate improved precise lane navigation of naval Amphibious Assault Vehicles (AAV) and Landing Craft Utility (LCU) using moving-map (MM) display.
- Measure navigation performance and assess crew workload: compare MM with “baseline” navigation methods.

# PROBLEMS

- For both AAV and LCU, one crewmember navigates while another drives
- Communication hampered by remote location of these crew from one other
- Need tool to improve communications and facilitate shared situational awareness (SA) among crew → should improve crew's ability to precisely navigate assault lanes

# LCU CREW



# AAV CREW

**Crew Chief**



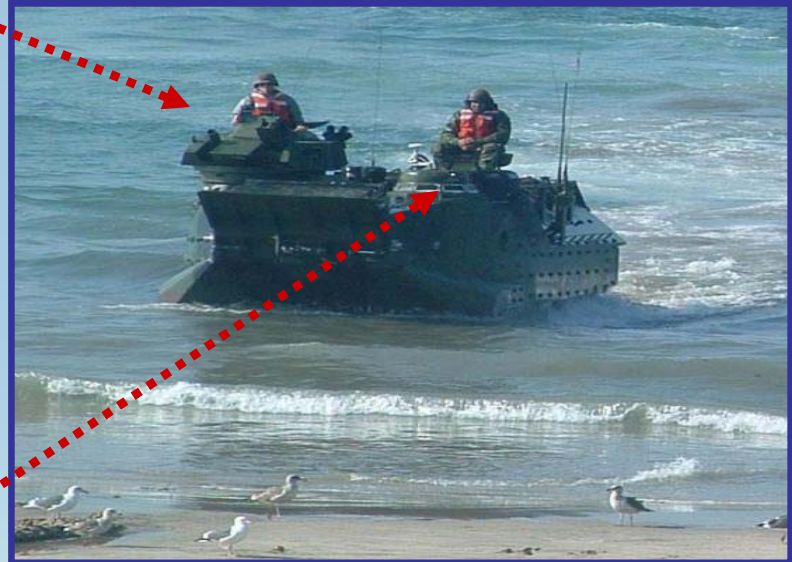
*Communicate (via  
intercom) course  
corrections with range  
and bearing*



**Driver**

*(relies solely on Crew Chief  
for direction)*

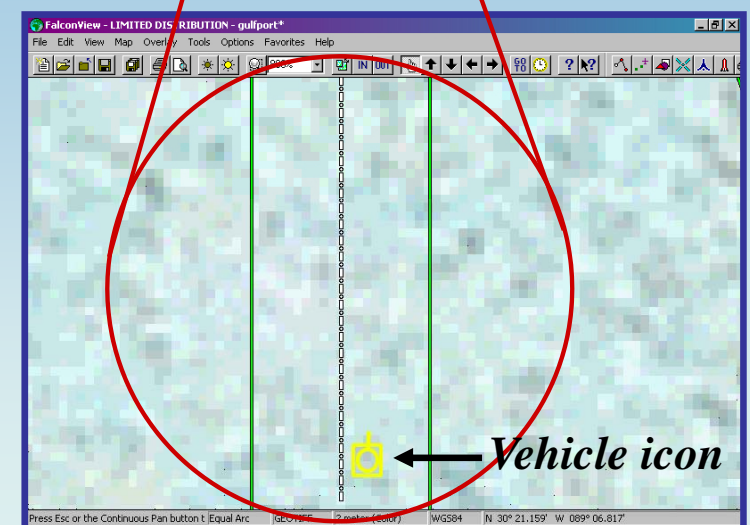
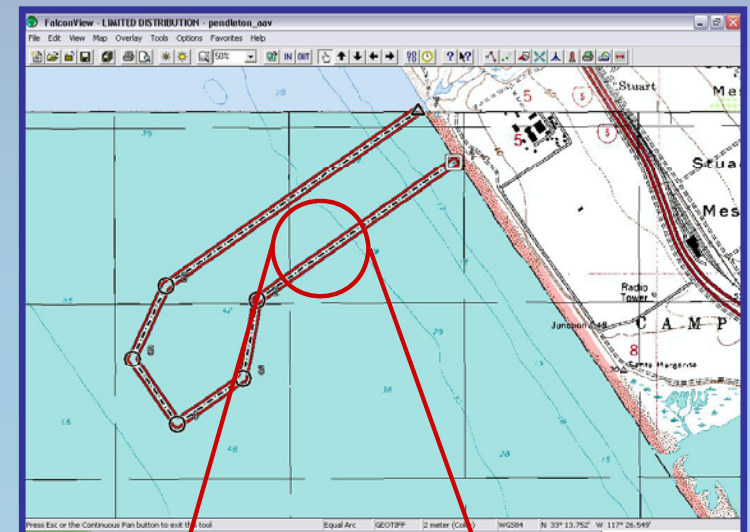
*Can go topside for 360°  
view of surrounding area*



*Always below deck with  
limited outside view*

# MM SOFTWARE

- GOTS Navy Portable Flight Planning System (N-PFPS) software; FalconView module
  - *GPS / Moving-Map tools*
  - *Auto scrolling*
  - *Track – up display*
- Loads all military standard NIMA / NOAA charts & maps and supports GEOTIFF
- Supports direct operator input of Assault Lanes Battle Space Geometry





# MM TESTS & DEMOS

FY02

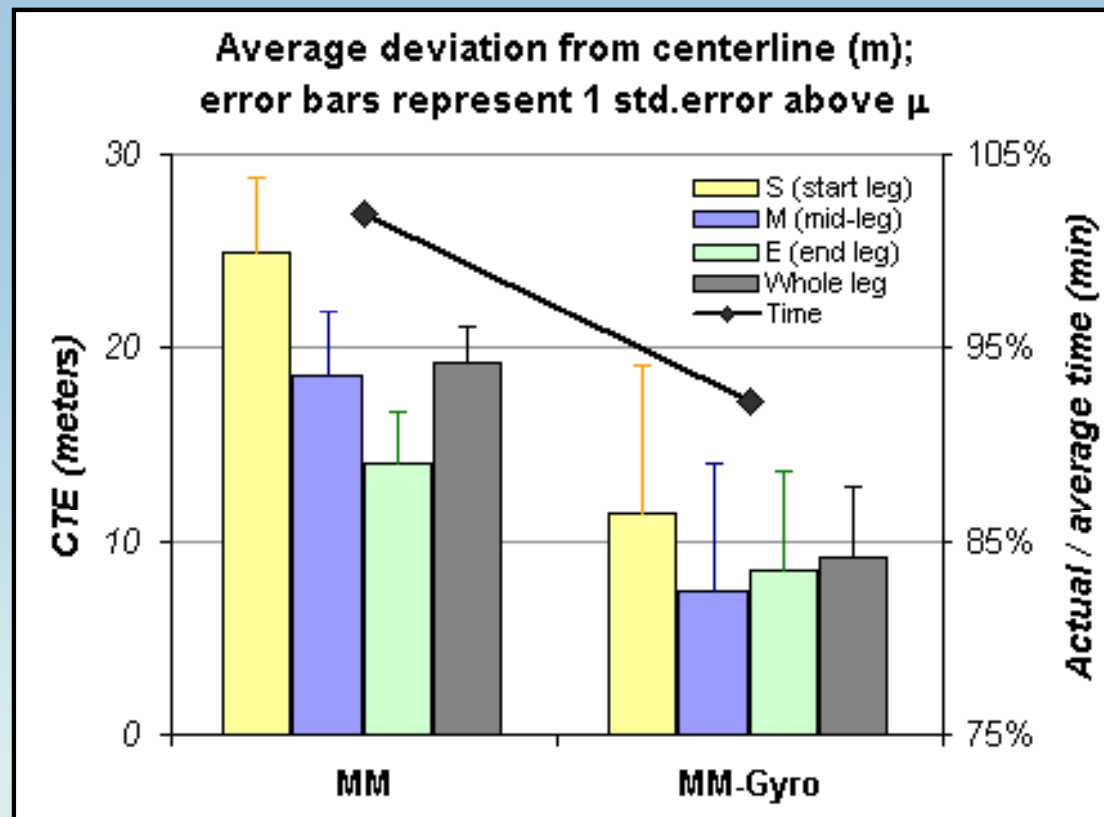
- May '02: AAV (Tests at 4th Assault Amphibian Battalion Reserve Unit, Gulfport, MS)
- July '02: AAV, LCU, LCAC (FBE-J, Camp Pendleton, CA)

FY03

- Oct '02: LCU (Testing gyrocompass input to MM; Little Creek, VA)
- Nov '02: AAV (Testing magnetic heading sensor input to MM, Camp Pendleton, CA)
- Jan '03: AAV, LCU (Transparent Hunter, San Diego and Camp Pendleton, CA)
- June '03: MM / ALNS field test, Panama City, FL

# HEADING SENSOR TESTS: LCU

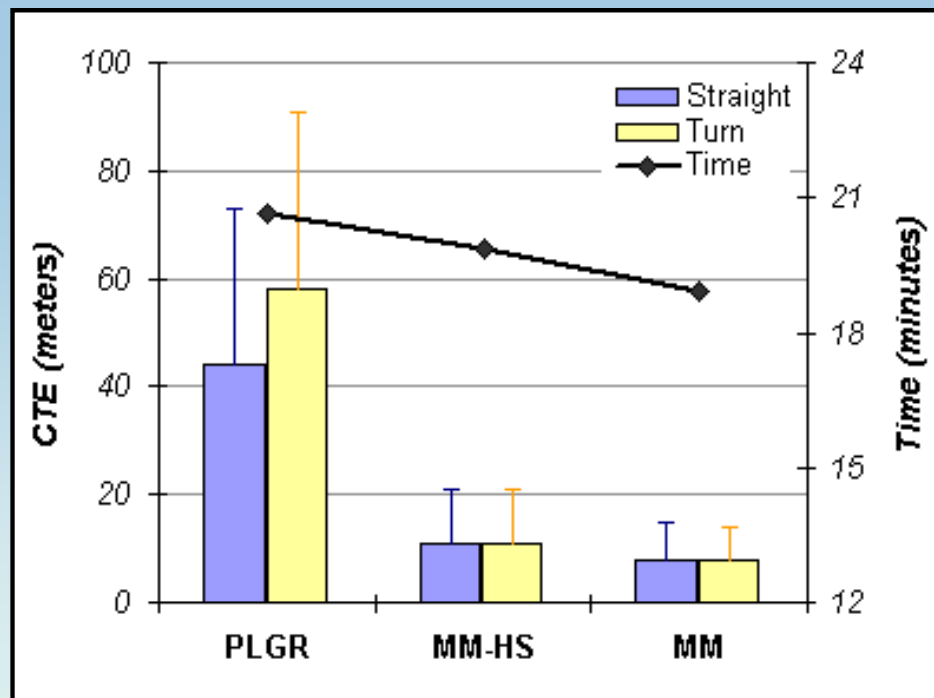
- Hypothesis: independent heading sensor would provide direction when vehicle at rest, stabilize map, and assist driver at start of track or during slow turns.



- Magnetic heading sensor ineffective in LCUs (metal).
- Little Creek LCUs had onboard gyrocompass and analog-to-digital converter.
- NRL wrote software to merge digital gyro signal with GPS signal into NMEA string and input to FalconView.
- Significant improvement in lane nav performance with gyro ( $\mu$  CTE = 9.1 m) vs. no gyro (19.2 m):  $t = 2.36$ ,  $p < 0.02$ .

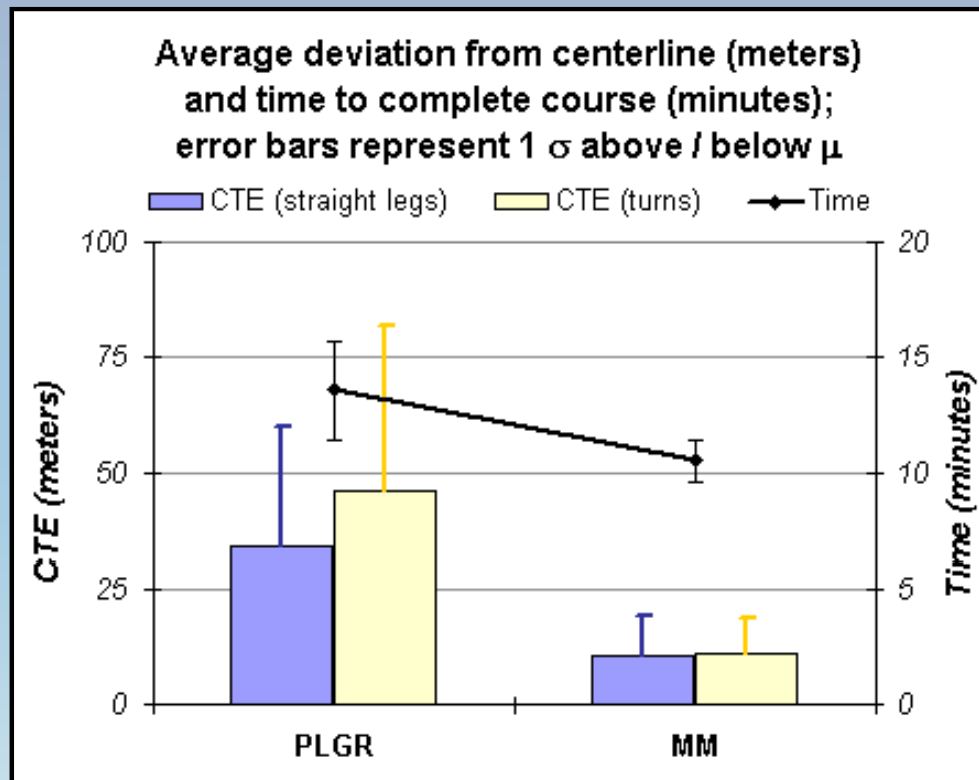
# HEADING SENSOR TESTS: AAV

- Magnetic heading sensor worked OK on AAV.
- NRL wrote software to merge heading sensor signal with GPS signal into single NMEA string and input to FalconView.



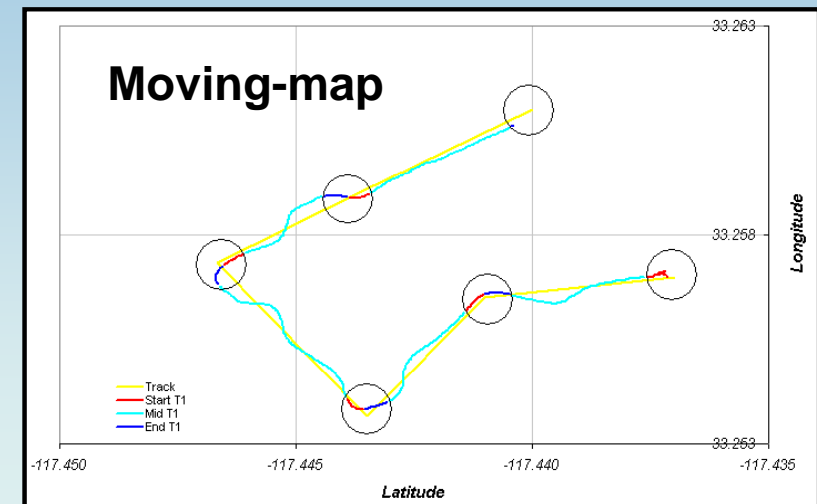
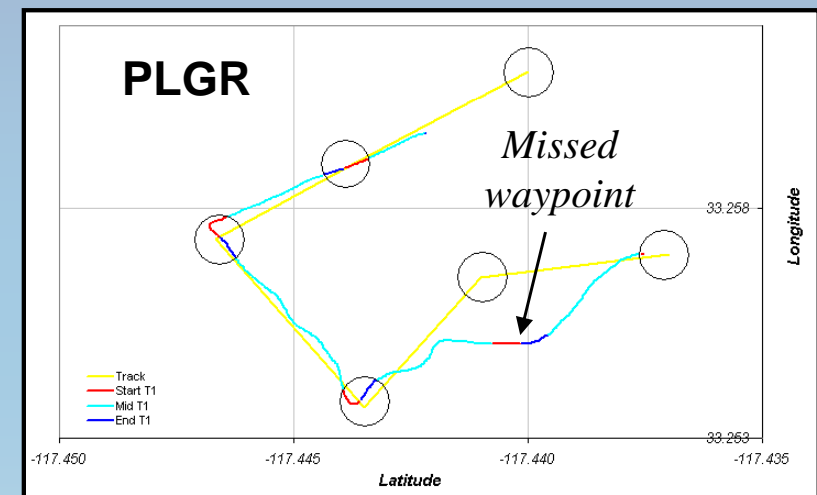
- Unexpected time lag introduced during signal merge; unable to fix during this field test.
- No AAV lane navigation improvement seen between MM with heading sensor vs. without (likely due to lag issue).

# SUMMARY OF AAV PERFORMANCE RESULTS FROM MM TESTS DURING TH03



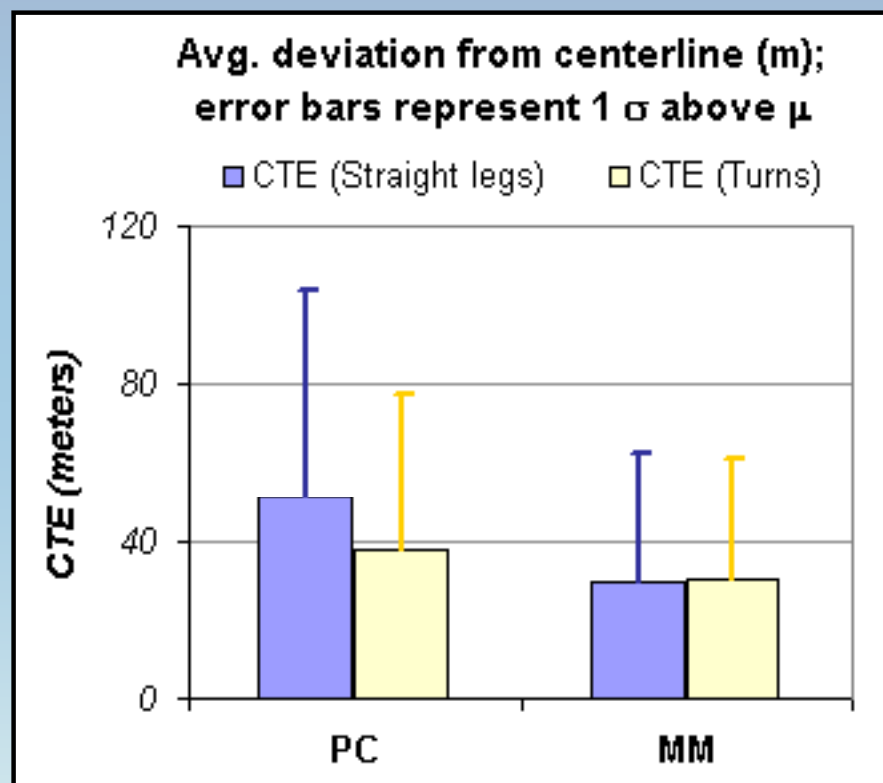
- MM significantly reduced required lane width, on average, compared with PLGR on straight legs ( $t = 5.24$ ,  $p < 0.0001$ ) and during turns ( $t = 4.61$ ,  $p = 0.0003$ ).
- MM significantly reduced time required to complete the course, compared with PLGR ( $t = 3.02$ ,  $p < 0.005$ ).

## Sample runs:

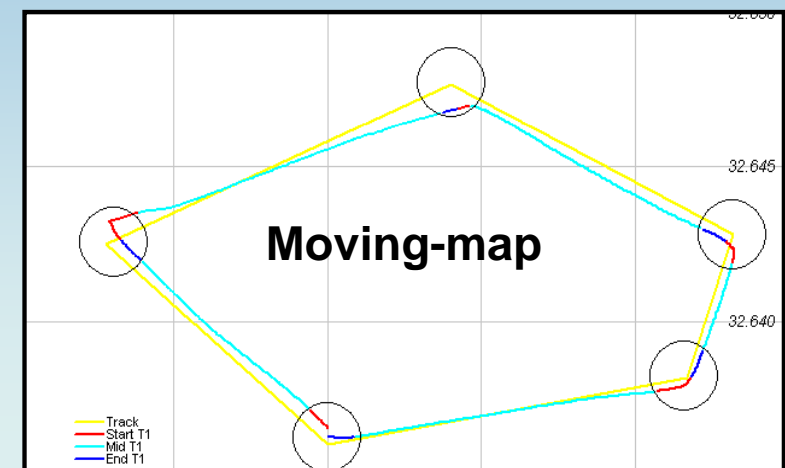
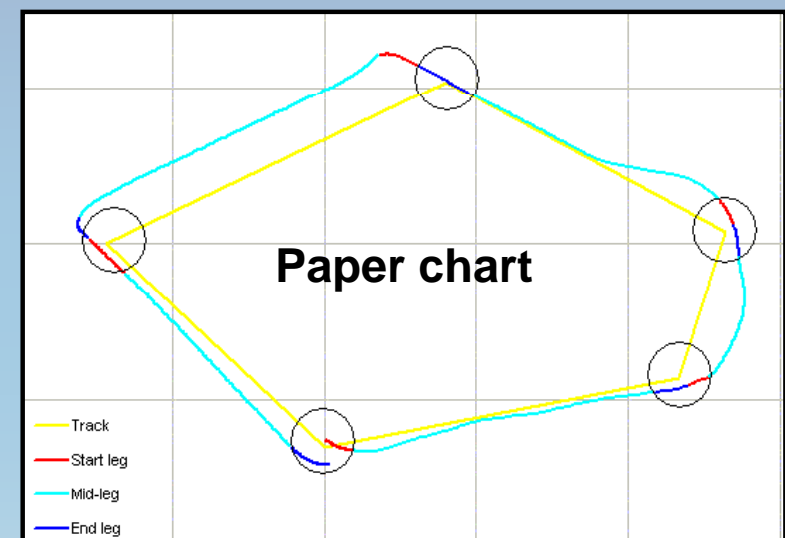


# SUMMARY OF LCU PERFORMANCE RESULTS FROM MM TESTS DURING TH03

## Sample runs:



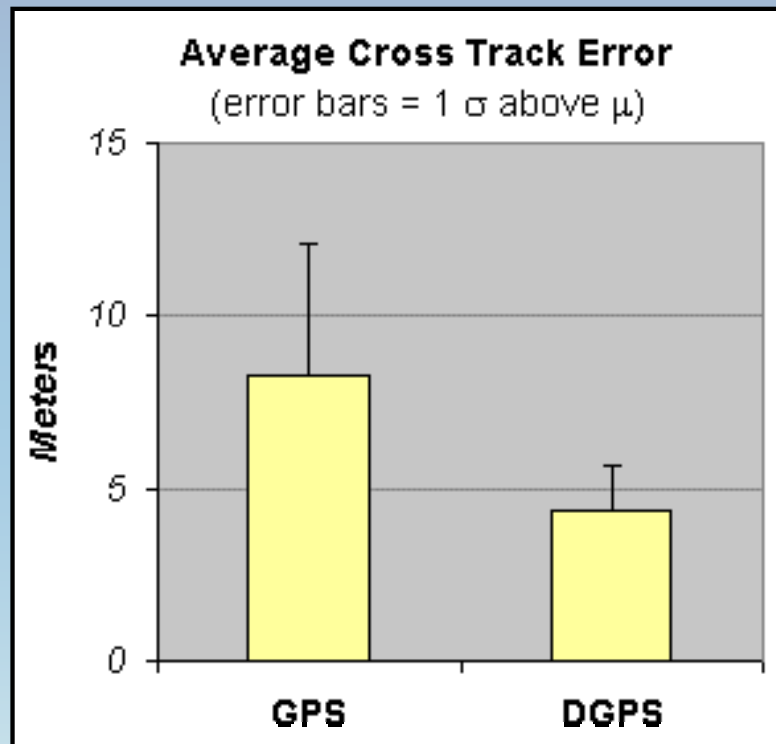
- MM reduced required lane width, on average, compared with paper chart, although T-test could not confirm significance (not enough paper chart runs).



# ALNS / MM RESULTS

- **ALNS and MM interfaced seamlessly: MM system successfully input ALNS-corrected GPS signals (in NMEA-0813 compliant format) in real-time and displayed boat position in track-up over a digital nautical chart of the operational area.**
- **Abundance of boat traffic during field tests precluded reasonable navigation performance comparisons among the three MM configurations (i.e., ALNS, GPS, DGPS).**
- **Most important metric was precision of ALNS positions compared with DGPS.**

# IMPORTANCE OF PRECISE POSITIONING

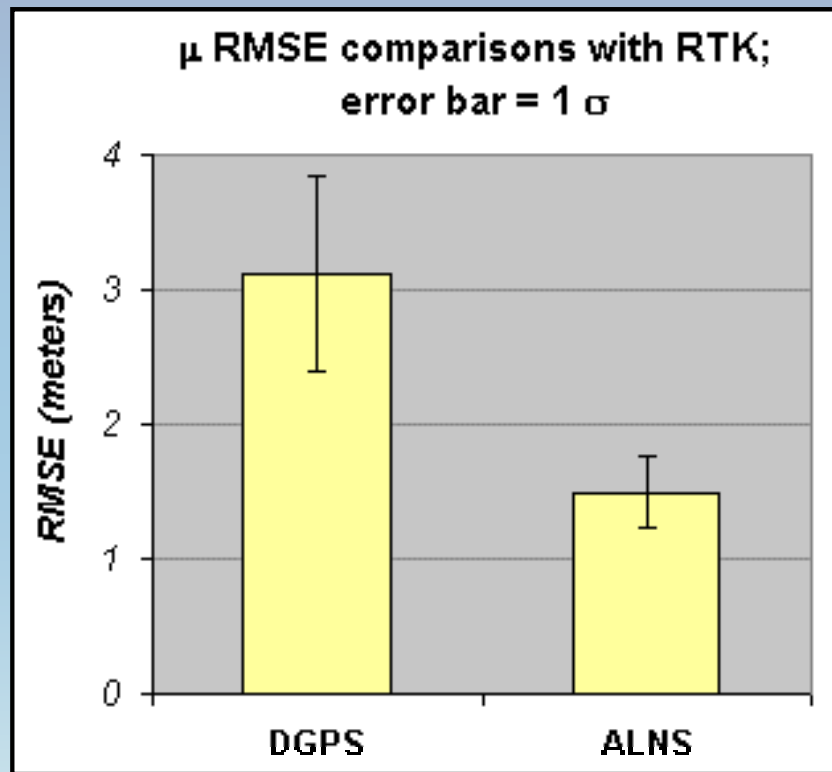


Difference in performance (CTE) between navigating with MM/GPS vs. MM/DGPS is significant:

$$t_{14df} = 2.91, p=0.01$$

- Result of NRL MM tests on AAVs (May'02, Gulfport): improved positioning precision (i.e., from GPS to DGPS) corresponded with improved driver's ability to follow the centerline of a preset lane.
- However, DGPS is not available globally.
- Proposed: ALNS can provide MM with DGPS precision on a global scale.

# ALNS/MM (CONTINUED)



ALNS surpassed DGPS precision  
on these tests, on average,  
compared with RTK:  
 $t_{14df} = 7.54, p < 0.0001$

- 9 runs with MM / ALNS
- 8 runs with MM / non-corrected GPS
- NRL logged DGPS position on 2<sup>nd</sup> MM system for comparison
- CSS logged boat position using real-time kinematic (RTK) system for common ground-truth on all runs
- RMSE betw. ALNS & RTK: 1.49 m
- RMSE betw. DGPS & RTK: 3.12 m
- ALNS / MM shows tremendous potential for improving SA and providing a globally available navigation aid with precision equivalent to DGPS



# CREW FEEDBACK

- **MM most useful for:**
  - *Staying on track*
  - *Anticipating turns*
  - *Aiming for waypoint*
  - *Traversing track quickly*
  - *Avoiding minefields rather than clearing mines*
- **Driver learned primary MM functions easily**
- **Crew recommendations for improvement:**
  - *Reduce size of screen and move to less intrusive location; in high seas, need to keep outside view (not focus on map).*
  - *Thermal imaging / moving map should be able to switch back / forth or display as picture within picture.*

# OTHER SUGGESTIONS

- Operator interface should be minimal.
- Declutter display; make it simple.
- Need a way to plan or mission re-plan on the fly (i.e., a way to dump new waypoints to the map quickly).
- Allow MM to input coordinates from PLGR.
- Can't rely on commercial GPS; need militarized GPS (ALNS?)
- Thermal imaging viewer: actual view out in front; may want to consider a "highway display" but would need a predictor capability to help anticipate next turn.
- Audible cues tied into head phones.
- Dim display for nighttime use (to minimize night blindness and chance for enemy NVGs to see you).
- Consider touch screen (but must withstand petroleum/grease).
- Make all hardware more waterproof!!

# SUMMARY

- NRL demonstrated that a moving-map system significantly improves lane navigation performance in AAV & LCU, compared with baseline nav. methods.
- NRL used GTRI FalconView as demo system: GOTS software with free licensing, operates on COTS Windows PC.
- NRL has software developers' tool kit (STK) for FalconView; can add new functionality to follow recommendations, if required.
- Next step: *Install moving-map (or ECDIS) on AAV, LCU?*

# NRL MM POCs

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